

$\Psi \vdash e : \sigma$

**S-T-VAR**

$$\frac{x : \sigma \in \Psi}{\Psi \vdash x : \sigma}$$

**S-T-ABS**

$$\frac{\Psi, x : \sigma_1 \vdash e : \sigma_2}{\Psi \vdash \lambda x. e : \sigma_1 \rightarrow \sigma_2}$$

**S-T-APP**

$$\frac{\Psi \vdash e_1 : \sigma_2 \rightarrow \sigma \quad \Psi \vdash e_2 : \sigma_2}{\Psi \vdash e_1(e_2) : \sigma}$$

**S-T-STRINGIN-I**

$$\frac{s \in \mathcal{L}\{r\}}{\Psi \vdash \text{rstr}[s] : \text{stringin}[r]}$$

**S-T-CONCAT**

$$\frac{\Psi \vdash e_1 : \text{stringin}[r_1] \quad \Psi \vdash e_2 : \text{stringin}[r_2]}{\Psi \vdash \text{rconcat}(e_1; e_2) : \text{stringin}[r_1 \cdot r_2]}$$

**S-T-CASE**

$$\frac{\Psi \vdash e_2 : \sigma \quad \Psi, x : \text{stringin}[\text{head}(r)], y : \text{stringin}[\text{ltail}(r)] \vdash e_3 : \sigma}{\Psi \vdash \text{rstrcase}(e_1; e_2; x, y. e_3) : \sigma}$$

**S-T-REPLACE**

$$\frac{\Psi \vdash e_1 : \text{stringin}[r_1] \quad \Psi \vdash e_2 : \text{stringin}[r_2] \quad \text{lreplace}(r; r_1; r_2) = r'}{\Psi \vdash \text{rreplace}[r](e_1; e_2) : \text{stringin}[r']}$$

**S-T-SAFECOERCE**

$$\frac{\Psi \vdash e : \text{stringin}[r'] \quad \mathcal{L}\{r'\} \subseteq \mathcal{L}\{r\}}{\Psi \vdash \text{rcoerce}[r](e) : \text{stringin}[r]}$$

**S-T-CHECK**

$$\frac{\Psi \vdash e_0 : \text{stringin}[r_0] \quad \Psi, x : \text{stringin}[r] \vdash e_1 : \sigma \quad \Psi \vdash e_2 : \sigma}{\Psi \vdash \text{rcheck}[r](e_0; x. e_1; e_2) : \sigma}$$

$e \Downarrow v$

<b>S-E-ABS</b> <hr style="border: 0.5px solid black;"/> $\lambda x. e \Downarrow \lambda x. e$	<b>S-E-APP</b> $\frac{e_1 \Downarrow \lambda x. e_3 \quad e_2 \Downarrow v_2 \quad [v_2/x]e_3 \Downarrow v}{e_1(e_2) \Downarrow v}$	<b>S-E-RSTR</b> <hr style="border: 0.5px solid black;"/> $\text{rstr}[s] \Downarrow \text{rstr}[s]$
<b>S-E-CONCAT</b> $\frac{e_1 \Downarrow \text{rstr}[s_1] \quad e_2 \Downarrow \text{rstr}[s_2]}{\text{rconcat}(e_1; e_2) \Downarrow \text{rstr}[s_1 s_2]}$	<b>S-E-CASE-<math>\epsilon</math></b> $\frac{e_1 \Downarrow \text{rstr}[e] \quad e_2 \Downarrow v_2}{\text{rstrcase}(e_1; e_2; x, y. e_3) \Downarrow v_2}$	
<b>S-E-CASE-CONCAT</b> $\frac{e_1 \Downarrow \text{rstr}[a.s] \quad [\text{rstr}[a], \text{rstr}[s]/x, y]e_3 \Downarrow v_3}{\text{rstrcase}(e_1; e_2; x, y. e_3) \Downarrow v_3}$		
<b>S-E-REPLACE</b> $\frac{e_1 \Downarrow \text{rstr}[s_1] \quad e_2 \Downarrow \text{rstr}[s_2] \quad \text{subst}(r; s_1; s_2) = s}{\text{rreplace}[r](e_1; e_2) \Downarrow \text{rstr}[s]}$	<b>S-E-SAFECOERCE</b> $\frac{e \Downarrow \text{rstr}[s]}{\text{rcoerce}[r](e) \Downarrow \text{rstr}[s]}$	
<b>S-E-CHECK-OK</b> $\frac{e \Downarrow \text{rstr}[s] \quad s \in \mathcal{L}\{r\} \quad [\text{rstr}[s]/x]e_1 \Downarrow v}{\text{rcheck}[r](e; x. e_1; e_2) \Downarrow v}$		
<b>S-E-CHECK-NOTOK</b> $\frac{e \Downarrow \text{rstr}[s] \quad s \notin \mathcal{L}\{r\} \quad e_2 \Downarrow v}{\text{rcheck}[r](e; x. e_1; e_2) \Downarrow v}$		

Figures 3 and 4: Typing Rules and Big step semantics for  $\lambda_{RS}$

$\langle \sigma \rangle ::= \sigma \rightarrow \sigma$ $\mid \text{stringin}[r]$	source types
$\langle e \rangle ::= x$ $\mid \lambda x.e$ $\mid e(e)$ $\mid \text{rstr}[s]$ $\mid \text{rconcat}(e; e) \mid \text{rstrcase}(e; e; x, y.e)$ $\mid \text{rreplace}[r](e; e)$ $\mid \text{rcoerce}[r](e) \mid \text{rcheck}[r](e; x.e; e)$	source terms $s \in \Sigma^*$
$\langle v \rangle ::= \lambda x.e \mid \text{rstr}[s]$	source values
$\langle \tau \rangle ::= \tau \rightarrow \tau$ $\mid \text{string}$ $\mid \text{regex}$	target types
$\langle \iota \rangle ::= x$ $\mid \lambda x.\iota$ $\mid \iota(\iota)$ $\mid \text{str}[s]$ $\mid \text{rx}[r] \mid \text{concat}(\iota; \iota) \mid \text{strcase}(\iota; \iota; x, y.\iota) \mid \text{replace}(\iota; \iota; \iota) \mid \text{check}(\iota; \iota; \iota)$	target terms
$\langle \upsilon \rangle ::= \lambda x.\iota \mid \text{str}[s] \mid \text{rx}[r]$	target values

Figures 2 and 5: Syntax of  $\lambda_{RS}$  and  $\lambda_P$ .

$\Theta \vdash \iota : \tau$

$\Theta ::= \emptyset \mid \Theta, x : \tau$

<p><b>P-T-VAR</b></p> $\frac{x : \tau \in \Theta}{\Theta \vdash x : \tau}$	<p><b>P-T-ABS</b></p> $\frac{\Theta, x : \tau_1 \vdash \iota_2 : \tau_2}{\Theta \vdash \lambda x. \iota_2 : \tau_1 \rightarrow \tau_2}$	<p><b>P-T-APP</b></p> $\frac{\Theta \vdash \iota_1 : \tau_2 \rightarrow \tau \quad \Theta \vdash \iota_2 : \tau_2}{\Theta \vdash \iota_1(\iota_2) : \tau}$
<p><b>P-T-STRING</b></p> <hr style="width: 100%;"/> <p><math>\Theta \vdash \text{str}[s] : \text{string}</math></p>	<p><b>P-T-REGEX</b></p> <hr style="width: 100%;"/> <p><math>\Theta \vdash \text{rx}[r] : \text{regex}</math></p>	<p><b>P-T-CONCAT</b></p> $\frac{\Theta \vdash \iota_1 : \text{string} \quad \Theta \vdash \iota_2 : \text{string}}{\Theta \vdash \text{concat}(\iota_1; \iota_2) : \text{string}}$
<p><b>P-T-CASE</b></p> $\frac{\Theta \vdash \iota_1 : \text{string} \quad \Theta \vdash \iota_2 : \tau \quad \Theta, x : \text{string}, y : \text{string} \vdash \iota_3 : \tau}{\Theta \vdash \text{strcase}(\iota_1; \iota_2; x, y. \iota_3) : \tau}$		
<p><b>P-T-REPLACE</b></p> $\frac{\Theta \vdash \iota_1 : \text{regex} \quad \Theta \vdash \iota_2 : \text{string} \quad \Theta \vdash \iota_3 : \text{string}}{\Theta \vdash \text{replace}(\iota_1; \iota_2; \iota_3) : \text{string}}$		
<p><b>P-T-CHECK</b></p> $\frac{\Theta \vdash \iota_r : \text{regex} \quad \Theta \vdash \iota_1 : \text{string} \quad \Theta \vdash \iota_2 : \sigma \quad \Theta \vdash \iota_3 : \sigma}{\Theta \vdash \text{check}(\iota_r; \iota_1; \iota_2; \iota_3) : \sigma}$		

$\iota \Downarrow \upsilon$

<b>P-E-ABS</b> <hr style="border: 0.5px solid black;"/> $\lambda x.e \Downarrow \lambda x.e$	<b>P-E-APP</b> $\frac{\iota_1 \Downarrow \lambda x.\iota_3 \quad \iota_2 \Downarrow \upsilon_2 \quad [\upsilon_2/x]\iota_3 \Downarrow \upsilon_3}{\iota_1(\iota_2) \Downarrow \upsilon_3}$	<b>P-E-STR</b> <hr style="border: 0.5px solid black;"/> $\text{str}[s] \Downarrow \text{str}[s]$
<b>P-E-RX</b> <hr style="border: 0.5px solid black;"/> $\text{rx}[r] \Downarrow \text{rx}[r]$	<b>P-E-CONCAT</b> $\frac{\iota_1 \Downarrow \text{str}[s_1] \quad \iota_2 \Downarrow \text{str}[s_2]}{\text{concat}(\iota_1; \iota_2) \Downarrow \text{str}[s_1 s_2]}$	<b>P-E-CASE-<math>\epsilon</math></b> $\frac{\iota_1 \Downarrow \text{str}[e] \quad \iota_2 \Downarrow \upsilon_2}{\text{strcase}(\iota_1; \iota_2; x, y.\iota_3) \Downarrow \upsilon_2}$
	<b>P-E-CASE-CONCAT</b> $\frac{\iota_1 \Downarrow \text{str}[a.s] \quad [\text{str}[a], \text{str}[s]/x, y]\iota_3 \Downarrow \upsilon}{\text{strcase}(\iota_1; \iota_2; x, y.\iota_3) \Downarrow \upsilon}$	
<b>P-E-REPLACE</b> $\frac{\iota_1 \Downarrow \text{rx}[r] \quad \iota_2 \Downarrow \text{str}[s_2] \quad \iota_3 \Downarrow \text{str}[s_3] \quad \text{subst}(r; s_2; s_3) = s}{\text{replace}(\iota_1; \iota_2; \iota_3) \Downarrow \text{str}[s]}$		

Figures 6 and 7: Typing rules and big step semantics for  $\lambda_P$

$\llbracket \sigma \rrbracket = \tau$	$\frac{\text{Tr-T-STRING}}{\llbracket \text{stringin}[r] \rrbracket = \text{string}}$	$\frac{\text{Tr-T-ARROW}}{\begin{array}{l} \llbracket \sigma_1 \rrbracket = \tau_1 \quad \llbracket \sigma_2 \rrbracket = \tau_2 \\ \llbracket \sigma_1 \rightarrow \sigma_2 \rrbracket = \tau_1 \rightarrow \tau_2 \end{array}}$	
$\llbracket \Psi \rrbracket = \Theta$	$\frac{\text{Tr-T-CONTEXT-EMP}}{\llbracket \emptyset \rrbracket = \emptyset}$	$\frac{\text{Tr-T-CONTEXT-EXT}}{\begin{array}{l} \llbracket \Psi \rrbracket = \Theta \quad \llbracket \sigma \rrbracket = \tau \\ \llbracket \Psi, x : \sigma \rrbracket = \Theta, x : \tau \end{array}}$	
$\llbracket e \rrbracket = \iota$	$\frac{\text{Tr-VAR}}{\llbracket x \rrbracket = x}$	$\frac{\text{Tr-ABS}}{\llbracket \lambda x.e \rrbracket = \lambda x.\iota}$	$\frac{\text{Tr-APP}}{\begin{array}{l} \llbracket e_1 \rrbracket = \iota_1 \quad \llbracket e_2 \rrbracket = \iota_2 \\ \llbracket e_1(e_2) \rrbracket = \iota_1(\iota_2) \end{array}}$
$\frac{\text{Tr-CASE}}{\llbracket \text{rstrcase}(e_1; e_2; x, y.e_3) \rrbracket = \text{strcase}(\iota_1; \iota_2; x, y.\iota_3)}$	$\frac{\text{Tr-STRING}}{\llbracket \text{rstr}[s] \rrbracket = \text{str}[s]}$		
$\frac{\text{Tr-CONCAT}}{\llbracket \text{rconcat}(e_1; e_2) \rrbracket = \text{concat}(\iota_1; \iota_2)}$	$\frac{\text{Tr-SUBST}}{\llbracket \text{rreplace}[r](e_1; e_2) \rrbracket = \text{replace}(\text{rx}[r]; \iota_1; \iota_2)}$		
$\frac{\text{Tr-SAFE} \text{COERCE}}{\llbracket \text{rcoerce}[r'](e) \rrbracket = \iota}$	$\frac{\text{Tr-CHECK}}{\llbracket \text{rcheck}[r](e; x.e_1; e_2) \rrbracket = \text{check}(\text{rx}[r]; \iota; (\lambda x.\iota_1)(\iota_2)}$		

Figure 8: Translation from source terms ( $e$ ) to target terms ( $\iota$ ).